Wood Beam calculation

Using Southern Pine No. 2 , therefore properties common to all Southern Pine $G := 0.55$

$L_b := 16\ ft$ $Trib := 1\ ft$ $\gamma := G \cdot 62.4\ \frac{lbf}{ft^3} = 34.32\ \frac{lbf}{ft^3}$

Use 2x10 for Joist application

$b := 1.5\ in$ $d := 9.25\ in$

$F_b := 800\ \frac{lbf}{in^2}$ $F_v := 175\ \frac{lbf}{in^2}$ $F_t := 475\ \frac{lbf}{in^2}$ $F_c := 1300\ \frac{lbf}{in^2}$ $E := 1400000\ \frac{lbf}{in^2}$

$S := \frac{b \cdot d^2}{6} = 21.3906\ in^3$ $I := \frac{b \cdot d^3}{12} = 98.93\ in^4$

$C_D := 1.0$ $C_{ME} := .9$ Adjustment Factor for E calcs

$E' := E \cdot C_{ME} = 1260\ \frac{kip}{in^2}$

$\frac{d}{b} = 6.1667$ $COV_E := .25$ Appendix F NDS

since $\frac{d}{b} > 6$ CL <> 1.0 $E'_{min} := E' \cdot \left(1 - 1.645 \cdot COV_E\right) \cdot \frac{1.03}{1.66} = 460.289\ \frac{kip}{in^2}$

Enercalc Calculations

Adjustment Factors for Bending:

if $F_b \le 1150\ \frac{lbf}{in^2} = 1$ see Wet Service Factor Table Footnote

$C_M := 1$

else

$C_M := .85$

$C_r := 1.15$

Beam Stability Factor

Lateral blocking spacing for buckling in ft $NumberOfIntermediateBlkgLocations := 16$

$l_u := \frac{L_b}{NumberOfIntermediateBlkgLocations + 1} = 0.9412\ ft$

Unbraced length that compression flange is not braced

$l_u = 11.2941\ in$

$\frac{l_u}{d} = 1.221$

if $\frac{l_u}{d} < 7$ $= 1.9388\ ft$

$l_e := 2.06 \cdot l_u$

else

$l_e := 1.63 \cdot l_u + 3 \cdot d$

$l_e = 1.9\ \text{ft}$

Table 3.3.3 for uniform load

This value is related to top and bottom

flange buckling, not overall member/col type

buckling

$R_B := \sqrt{\frac{l_e \cdot d}{b^2}} = 9.78$

if $R_B < 50 =$ "PASS" <<<<<CHECK

"PASS"

else

"FAIL"

$E'_{min} := E' \cdot \left(1 - 1.645 \cdot COV_E\right) \cdot \frac{1.03}{1.66} = 460.3\ \frac{\text{kip}}{\text{in}^2}$

$F_{bE} := \frac{1.2 \cdot E'_{min}}{R_B^2} = 5.7747\ \frac{\text{kip}}{\text{in}^2}$

$F'_b := F_b \cdot C_D \cdot C_M \cdot C_r = 0.92\ \frac{\text{kip}}{\text{in}^2}$ Does not matche Enercalc due to CM factor footnote, see above

$$C_L := \frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9} - \sqrt{\left(\frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9}\right)^2 - \frac{\left(\frac{F_{bE}}{F'_b}\right)}{.95}} = 0.9907$$

$F'' := F'_b \cdot C_L = 0.9115\ \frac{\text{kip}}{\text{in}^2}$

Load Calcs

$Wght := \frac{b \cdot d \cdot 12\ \text{in} \cdot \gamma}{\text{ft}} = 3.3069\ \frac{\text{lbf}}{\text{ft}}$ $c := \frac{d}{2} = 4.625\ \text{in}$

Loading

$DL := 10\ \frac{\text{lbf}}{\text{ft}^2} - 3.3069\ \frac{\text{lbf}}{\text{ft}^2}$ $L := 40\ \frac{\text{lbf}}{\text{ft}^2}$ $L_r := 20\ \frac{\text{lbf}}{\text{ft}^2}$ $SL := 40\ \frac{\text{lbf}}{\text{ft}^2}$ $WL := 10\ \frac{\text{lbf}}{\text{ft}^2}$

$D := DL \cdot Trib + Wght = 10\ \frac{\text{lbf}}{\text{ft}}$ $L := L \cdot Trib = 40\ \frac{\text{lbf}}{\text{ft}}$

$L_r := L_r \cdot Trib = 20\ \frac{\text{lbf}}{\text{ft}}$ $SL := SL \cdot Trib = 40\ \frac{\text{lbf}}{\text{ft}}$ $W := WL \cdot Trib = 10\ \frac{\text{lbf}}{\text{ft}}$

ft ft ft

$L_{LorR} := \max\left(\left[\begin{array}{cc} L_r & L \end{array}\right]\right) = 40\ \frac{lbf}{ft}$

$W_1 := D + L_{LorR} = 50\ \frac{lbf}{ft}$ $W_2 := D + SL = 50\ \frac{lbf}{ft}$

$W_3 := D = 10\ \frac{lbf}{ft}$ $W_4 := D + W = 20\ \frac{lbf}{ft}$

$W_5 := D + .75 \cdot L_{LorR} + .75 \cdot SL = 70\ \frac{lbf}{ft}$ $W_6 := D + .75 \cdot L_{LorR} + .75 \cdot SL + .45 \cdot W = 74.5\ \frac{lbf}{ft}$

Based on Live Load Combination Loading

Bending

$w_{max} := W_1 = 50\ \frac{lbf}{ft}$

$M := \frac{w_{max} \cdot L_b^{\,2}}{8} = 1.6\ ft\ kip$

$f_b := \frac{M \cdot c}{I} = 897.589\ \frac{lbf}{in^2}$

$UC_{bend} := \frac{f_b}{F''} = 0.9848$

if $UC_{bend} < 1 =$ "PASS" <<<<<CHECK

"PASS"

else

"FAIL"

Shear (Matches Enercalc)

$C_M := .97$

$V_{at\_d\_dist} := w_{max} \cdot \left(L_b - d\right) - \frac{w_{max} \cdot L_b}{2} = 0.3615\ kip$

$f_v := \frac{3 \cdot V_{at\_d\_dist}}{2 \cdot b \cdot d} = 0.0391\ \frac{kip}{in^2}$

$F'_v := F_v \cdot C_D \cdot C_M = 0.1698\ \frac{kip}{in^2}$

$UC_{shear} := \frac{f_v}{F'_v} = 0.2302$

if $UC_{shear} < 1 =$ "PASS" <<<<<CHECK

"PASS"

else

"FAIL"

Based on Snow Combination Loading

$C_D := 1.15$

$F'_b := F_b \cdot C_D \cdot C_M \cdot C_r = 1026.26 \frac{lbf}{in^2}$

$C_L := \frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9} - \sqrt{\left(\frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9}\right)^2 - \frac{\left(\frac{F_{bE}}{F'_b}\right)}{.95}} = 0.9894$

$F''_b := F'_b \cdot C_L = 1015.4276 \frac{lbf}{in^2}$

$M := \frac{W_2 \cdot L_b^2}{8} = 1.6 \text{ ft kip}$

$f_b := \frac{M \cdot c}{I} = 897.589 \frac{lbf}{in^2}$

$UC_{bending} := \frac{f_b}{F''_b} = 0.884$

if $UC_{bending} < 1 =$ "PASS" <<<<<CHECK

"PASS"

else

"FAIL"

$V := \frac{W_2 \cdot L_b}{2} = 0.4 \text{ kip}$

$f_v := \frac{3 \cdot V}{2 \cdot b \cdot d} = 0.0432 \frac{kip}{in^2}$

$F'_v := F_v \cdot C_D \cdot C_M = 0.1952 \frac{kip}{in^2}$

$UC_{shear} := \frac{f_v}{F'_v} = 0.2215$

if $UC_{shear} < 1 =$ "PASS" <<<<<CHECK

"PASS"

else

"FAIL"

Base on Wind Combinations

$C_D := 1.6$

$F'_b := F_b \cdot C_D \cdot C_M \cdot C_r = 1427.84 \frac{lbf}{in^2}$

$$C_L := \frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9} - \sqrt{\left(\frac{1 + \left(\frac{F_{bE}}{F'_b}\right)}{1.9}\right)^2 - \frac{\left(\frac{F_{bE}}{F'_b}\right)}{.95}} = 0.9842$$

$$F''_b := F'_b \cdot C_L = 1405.2435 \ \frac{lbf}{in^2}$$

$$w_{max} := \max\left(\begin{bmatrix} 0 & 0 & 0 \\ W_4 & 0 & W_6 \end{bmatrix}\right) = 74.5 \ \frac{lbf}{ft}$$

$$M := \frac{w_{max} \cdot L_b^2}{8} = 2.384 \ ft \ kip$$

$$f_b := \frac{M \cdot c}{I} = 1337.4079 \ \frac{lbf}{in^2}$$

$$UC_{bending} := \frac{f_b}{F''_b} = 0.9517$$

```
if UC_bending < 1 = "PASS"
  "PASS"
else
  "FAIL"
```

<<<<<CHECK

$$V := \frac{w_{max} \cdot L_b}{2} = 0.596 \ kip$$

$$f_v := \frac{3 \cdot V}{2 \cdot b \cdot d} = 0.0644 \ \frac{kip}{in^2}$$

$$F'_v := F_v \cdot C_D \cdot C_M = 0.2716 \ \frac{kip}{in^2}$$

$$UC_{shear} := \frac{f_v}{F'_v} = 0.2372$$

```
if UC_shear < 1 = "PASS"
  "PASS"
else
  "FAIL"
```

<<<<<CHECK

Actual Deflection and Ratio Checks

Based on Foor or Roof Live Loads only

$$\Delta_{ST} := \frac{5 \cdot L_{LorR} \cdot L_b^4}{I \cdot E' \cdot 384} = 0.4732 \ in \qquad Ratio := \frac{L_b}{\Delta_{ST}} = 405.7743$$

```
if Ratio > 360 = "PASS"
  "PASS"
else
  "FAIL"
```

<<<<<CHECK

$$\Delta_{TOT} := \frac{5 \cdot \left(W_1\right) \cdot L_b^4}{I \cdot E' \cdot 384} = 0.5915 \ in \qquad Ratio := \frac{L_b}{\Delta} = 324.6196$$

```
if Ratio > 240 = "PASS"
  "PASS"
```

<<<<<CHECK

Δ_{TOT}

"PASS"
else
"FAIL"

Based on Snow or Wind Loads only

$SW_{max} := \max([\ SL\ \ W\ ]) = 40\ \frac{lbf}{ft}$

$\Delta_{SW} := \frac{5 \cdot SW_{max} \cdot L_b^{\ 4}}{I \cdot E' \cdot 384} = 0.4732\ in$ $Ratio := \frac{L_b}{\Delta_{SW}} = 405.7743$ if $Ratio > 360 =$ "PASS" <<<<<CHECK

"PASS"
else
"FAIL"

Total Deflection Based on outdoor deck use with snow and wind

$SW_{max} := \max([\ W_5\ \ W_6\ ]) = 74.5\ \frac{lbf}{ft}$

$\Delta_{TOT} := \frac{5 \cdot SW_{max} \cdot L_b^{\ 4}}{I \cdot E' \cdot 384} = 0.8813\ in$ $Ratio := \frac{L_b}{\Delta_{SW}} = 405.7743$ if $Ratio > 240 =$ "PASS" <<<<<CHECK

"PASS"
else
"FAIL"

For better floor performance and for seasoned wood used indoors:

$D := 0.5 \cdot D = 5\ \frac{lbf}{ft}$ Ratio of deflection from D+L to be less than L/360 (not 240)

$w_{L.D} := D + L = 45\ \frac{lbf}{ft}$

$\Delta_{totL.D} := \frac{5 \cdot (w_{L.D}) \cdot L_b^{\ 4}}{I \cdot E' \cdot 384} = 0.5323\ in$ $Ratio := \frac{L_b}{\Delta_{totL.D}} = 360.69$ if $Ratio > 360 =$ "PASS" <<<<<CHECK

"PASS"
else
"FAIL"

Creep - Deflection including creep

$K_{cr} := 2$ (2.0 for wet service conditions) --Ref NDS Specifications 3.5 Bending Members

Outdoor based on snow and wind

$\Delta_{LT} := \frac{5 \cdot (W_3) \cdot L_b^{\ 4}}{I \cdot E' \cdot 384} = 0.12\ in$

$W_5 := W_5 - W_3$ $W_6 := W_5 - W_3$

$W_{MAX} := \max\left(\left[\begin{matrix} W_5 \\ W_6 \end{matrix}\right]\right) = 60\ \frac{lbf}{ft}$

$\Delta_{ST} := \frac{5 \cdot W_{MAX} \cdot L_b^{\ 4}}{I \cdot E' \cdot 384} = 0.7098\ in$

$\Delta_{tot} := K_{cr} \cdot \Delta_{LT} + \Delta_{ST} = 0.95\ in$ $Ratio := \frac{L_b}{\Delta_{tot}} = 202.8873$ if $Ratio > 240 =$ "FAIL" <<<<<CHECK

"PASS"
else
"FAIL"